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Formulation and evaluation of sensory characteristics of functional food 'Ceremoringa Bar' made from moringa leaves (*Moringa oleifera*)

Formulasi dan evaluasi karakteristik sensori pangan fungsional 'Ceremoringa Bar' berbasis daun kelor (Moringa oleifera)

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Abstract

The success of breastfeeding is mediated by several variables, including maternal nutritional status. Moringa oleifera leaves are a nutrient-rich, locally available food source that may be cultivated as a functional snack for the maternal diet during pregnancy and lactation. Moringa dietary snack foods with acceptable sensory attributes are still limited in the market. This study attempted to produce a functional food product from moringa leaves (Ceremoringa Bar) and evaluate its sensory behavior for possible formulations with suitable acceptance. This experimental laboratory study was conducted at the Poltekkes Kemenkes Surabaya Food Processing Laboratory between August and October 2025. Nine Ceremoringa moringa formulations were prepared according to three processing processes (no heating, cooking without water addition, and cooking with water addition) added to dried apple, papaya, or strawberry. Sensory evaluation was conducted by 25 trained panelists using a 5-points hedonic scale covering color, aroma, taste, and texture. Data analysis relied on the Friedman test, followed by the Wilcoxon signed-rank test with Bonferroni correction. The participants assessed the sensory attributes significantly differently ($p < 0.05$). Post-hoc analysis was performed but found no differences between the formulation pairs. Formulation 3C also appeared to have the highest consistency of sensory acceptance, especially regarding texture, based on median and interquartile range assessments. In conclusion, Ceremoringa Bar displayed good sensory tolerance and can be used as a moringa-based functional snack to aid maternal nutrition. However, its biological effects on lactation have not yet been measured.

Keywords: Functional food, maternal nutrition, sensory test, snack bars

Abstrak

Daun moringa oleifera adalah sumber makanan lokal yang kaya akan senyawa bergizi dan dapat digunakan sebagai makanan fungsional untuk nutrisi ibu selama kehamilan dan menyusui. Namun, produk makanan berbasis moringa yang memenuhi penerimaan sensorik masih jarang. Tujuan dari penelitian ini adalah untuk mengembangkan makanan fungsional dari daun moringa (Ceremoringa Bar) dan memeriksa fitur sensoriknya untuk mendeteksi yang lebih umum dapat dimakan dengan penerimaan yang lebih baik. Sebuah eksperimen laboratorium juga dilakukan di Laboratorium Pengolahan Makanan Politeknik Kesehatan Kementerian Kesehatan Surabaya dari Agustus hingga Oktober 2025. Sembilan formulasi Ceremoringa Bar disiapkan menggunakan tiga metode pengolahan (tanpa pemanasan, dimasak tanpa menambahkan air, dan dimasak dengan menambahkan air) bersama dengan apel kering, pepaya, atau stroberi. Sebanyak 25 panelis terlatih dievaluasi menggunakan skala hedonik 5 poin untuk penilaian sensorik warna, aroma, rasa, dan tekstur. Untuk menyelidiki pengukuran berulang, data dianalisis menggunakan uji Friedman (uji non-parametrik), dan uji peringkat bertanda

Wilcoxon sebagai analisis post-hoc. Hasil uji Friedman menunjukkan perbedaan besar dalam penilaian sensorik warna, aroma, rasa, dan tekstur ($p < 0,05$). Namun, analisis post-hoc tidak menunjukkan perbedaan signifikan antara pasangan formulasi. Formulasi 3C menunjukkan stabilitas persepsi sensorik yang lebih tinggi dengan tekstur yang lebih konsisten. Kesimpulan, Ceremoringa Bar memiliki penerimaan sensorik yang baik dan dapat ditetapkan sebagai makanan fungsional berbasis moringa untuk ibu hamil dan menyusui untuk memenuhi kebutuhan nutrisi mereka, dan pengaruh biologisnya dalam menyusui dan laktasi tidak diuji dalam tinjauan saat ini.

Kata Kunci: Daun moringa (Moringa oleifera), makanan fungsional, nutrisi ibu, snack bar, uji sensorik

Introduction

Breast milk is the most optimal source of nutrition for babies because it contains complete nutrients and immune components that play an important role in growth and survival, especially at the age of 0-6 months. Exclusive breastfeeding has been proven to reduce the frequency of babies aged 0-12 months in West Surabaya (Fitri & Shofiya, 2020; Al Rahmad et al., 2024). For mothers, this practice helps speed up postpartum recovery, reduces the risk of breast and ovarian cancer, and strengthens the emotional bond between mother and child (Yelvianti, 2025). Therefore, the UNICEF and WHO recommend exclusive breastfeeding for the first six months of life, starting within the first hour after birth. Without any additional food or drink, exclusive breastfeeding also contributes to the sensory and cognitive development of infants and protects against various infectious and chronic diseases.

In Indonesia, the coverage of exclusive breastfeeding for infants aged 0–6 months shows variation and has not fully reached the expected target. Data from the 2023 Indonesian Health Survey (SKI) show that exclusive breastfeeding coverage for infants aged six months reached 63.9%, exceeding the 2023 national target of 50% (Ministry of Health, 2024). Although the trend is improving, this achievement still needs to be improved to approach the WHO recommendation of exclusive breastfeeding for all infants aged 0-6 months. Meanwhile, the 2025 UNICEF and WHO report notes that exclusive breastfeeding coverage in Indonesia in 2024 reached approximately 66.4%, up from 52% in 2017, although the proportion of infants receiving full breastfeeding until six months of age is still not optimal (World Health Organization, 2025).

However, various obstacles to breastfeeding remain common. The success of exclusive breastfeeding is influenced by various multidimensional factors, including breastfeeding experience (primiparity), the mother's psychological condition, such as anxiety, socioeconomic status, workplace support, and obstetric factors, such as cesarean delivery. These factors have been collectively reported to contribute to delayed lactation onset and low exclusive breastfeeding sustainability (Agampodi et al., 2021; Ekholuenetale et al., 2021; Hernández-vásquez, 2022; Lindblad et al., 2022; Shofiya et al., 2023, 2025; Taha et al., 2021).

Additionally, maternal nutritional status during pregnancy plays a crucial role in breastfeeding success, with mothers who are overweight or obese having a higher risk of experiencing delayed lactogenesis II than mothers with normal nutritional status, which can ultimately hinder exclusive breastfeeding practices (Montana et al., 2024; Pramesi et al., 2021; Shofiya et al., 2020). These challenges often manifest as complaints of breast pain, difficulties in the latching process, and mothers' perceptions of insufficient breast milk production, particularly among mothers with limited breastfeeding experience (Emagneneh et al., 2025).

One effective way to reduce the barriers to exclusive breastfeeding is to use natural functional foods, such as moringa leaves. Safe and effective support is needed to facilitate milk production. One well-known option is moringa leaves, which have the potential to be used as a functional food to support lactation. Nutritionally, moringa leaves are highly nutritious and contain up to seven times more vitamin C than oranges. In 100 g of fresh moringa leaves, there are 92 kcal of energy, 6.7 g of protein, 1.7 g of fat, and 12.5 g of carbohydrates, as well as various vitamins, minerals, essential amino acids, and phenolic compounds that play a role in boosting immunity and act as antioxidants (Hernita et al., 2024). Several studies have reported the use of moringa leaves for nutritional

support during breastfeeding; however, these studies did not directly evaluate the biological effects of moringa leaves on breast milk production (Nugrawati & Ekawati, 2025).

Snack bars have advantages because they are practical, easy to consume, and have the potential to be an alternative food source. The development of moringa leaf-based snack bars requires the right formulation, including the selection of processing methods and additives, to produce products with acceptable sensory characteristics that meet consumer preferences. Different processing methods can affect sensory attributes such as color, aroma, taste, and texture, as can variations in the types of dried fruits used as additives in the formulation. Although the potential of moringa leaves as a food ingredient has been widely studied, research specifically on the development of moringa leaf-based snack bars using a combination of processing methods and variations in dried fruit types, as well as systematic evaluation of the sensory acceptance of the product, is still limited. Therefore, this study is novel in the development of Ceremoringa Bar through the application of three processing methods, namely without heating, cooked without adding water, and cooked with added water, which are combined with three types of dried fruit, with a focus on evaluating the sensory characteristics of the product.

This study aimed to develop a Ceremoringa Bar formulation based on Moringa leaves and evaluate its sensory characteristics to determine the most acceptable formulation as the initial stage of developing functional foods based on Moringa leaves.

Methods

Study Design

This study used a laboratory experimental design with a *repeated measures* approach (within-subject design), in which each panelist assessed all the product formulations tested. The inclusion criteria for the panelists were as follows: active students in the Nutrition Study Program aged 18–25 years, in good health, without any disorders of taste or smell, and willing to participate in the entire testing process. The exclusion criteria included panelists who were allergic to any of the product ingredients, were experiencing health problems that could affect sensory perception, or did not complete the entire assessment session.

Location and Time

This study was conducted at the Food Processing Laboratory of the Surabaya Ministry of Health Polytechnic. The research was conducted from August to October 2025, covering the stages of material preparation, production of the Ceremoringa Bar, sensory testing, and data analysis.

Ingredients and Product Preparation

Table 1. Ingredient composition of Ceremoringa Bar per recipe

Ingredient	Amount (g)
Moringa leaf powder	7
Skim milk powder	30
Rice Krispies	5
Oats	5
Dried fruit*	15
Chocolate bars	250
Mineral water	25 ml

**Dried fruits include apples (A), papayas (B), and strawberries (C). Each formulation used one type of dried fruit.*

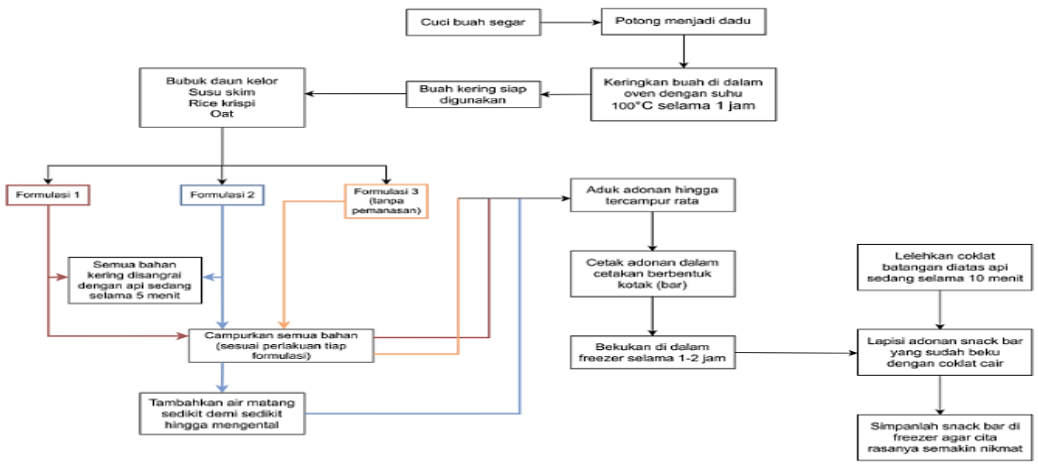

Figure 1. Ceremoringa Bar production process

Three processing methods were tested: formulation 1 was cooked without adding water, formulation 2 was cooked with the addition of water until the mixture thickened, and formulation 3 was prepared without heating (direct mixing). Three processing methods were compared to identify the most effective technique for producing a stable, dense, and homogeneous snack bar structure, as required for cereal-based products. Each processing method was combined with three dried fruit variants (A = apple, B = papaya, and C = strawberry), resulting in nine formulations: 1A, 1B, 1C, 2A, 2B, 2C, 3A, 3B, and 3C.

Panelists and Sensory Evaluation

Sensory testing was conducted by 25 trained panelists who were students in the Nutrition Study Program. The panelists were selected because they had a basic understanding of food sensory evaluation and had received brief training on hedonic testing procedures before the study. The panelists evaluated all the Ceremoringa Bar formulations using a 5-point hedonic scale for the attributes of color, aroma, taste, and texture.

Data collection

Research data were collected through hedonic sensory testing of nine Ceremoringa Bar formulations produced using a combination of processing methods and dried fruit types. Each panelist assessed all formulations (repeated measures design) using a 5-point hedonic scale (1 = strongly dislike to 5 = strongly liked) for the attributes of color, aroma, taste, and texture. Samples were presented randomly using a three-digit code to minimize identification bias, with breaks between assessments accompanied by mineral water to cleanse the palate.

All assessments were conducted individually in a laboratory sensory-testing room under controlled environmental conditions. The panelist scores were recorded on structured assessment sheets and collected as primary data for statistical analysis.

Statistical Analysis

Sensory test data were analyzed using the Friedman test as a nonparametric method for repeated measures data to identify differences in sensory characteristics between the formulations. If significant results were obtained, the analysis was continued with the Wilcoxon signed-rank test as a paired follow-up test, accompanied by the application of the Bonferroni correction to control the risk of type I error. The significance level was set at $\alpha = 0.05$.

Ethical Considerations

This research protocol was reviewed and approved by the Health Research Ethics Committee of the Surabaya Ministry of Health Polytechnic (No. EA/3799/KEPK-Poltekkes_Sby/V/2025). The sensory panelists participated voluntarily and signed an informed consent form prior to the evaluation.

Result and Discussion

Sensory tests were conducted on nine Ceremoringa Bar formulations produced using a combination of three processing methods and three types of dried fruit. The assessment included the attributes of color, aroma, taste, and texture using a 5-point hedonic scale. As each panelist assessed all formulations, the data were analyzed using the Friedman nonparametric test as a repeated measures test.

Sensory Descriptive Statistics

The sensory evaluation results are presented as the median and interquartile range (IQR) for each formulation.

Table 2. Median and IQR of Ceremoringa Bar Scores

Formulation	Color Median (IQR)	Aroma Median (IQR)	Taste Median (IQR)	Texture Median (IQR)
1A	3 (1)	3 (2)	4 (3)	3 (2)
1B	3 (2)	3 (1)	4 (1)	3 (2)
1C	3 (1)	3 (1)	3 (1)	4 (2)
2A	3 (1)	3 (1)	3 (1)	2 (1)
2B	3 (2)	3 (2)	2 (1)	3 (1)
2C	3 (1)	3 (1)	3 (1)	3 (2)
3A	3 (1)	3 (1)	3 (2)	2 (1)

3B	3 (1)	3 (1)	3 (2)	3 (1)
3C	3 (1)	3 (2)	3 (1)	4 (1)

All formulations had median ratings in the neutral-to-favorable category (median = 3–4). The color and aroma attributes showed a relatively uniform distribution of values across the formulations, with some formulations, such as 2C and 3C, having a narrower IQR, indicating consistency in the panelist perception. The taste and texture attributes showed more obvious variations in acceptance, with formulation 1A having the highest median taste [4 (2–5)], while formulation 3C showed the highest median texture [4 (3–4)] with a more consistent distribution.

Friedman Test Results

The Friedman test results showed significant differences between the Ceremoringa Bar formulations in all sensory attributes tested, including color (χ^2 = 28.502; df = 8; p < 0.001), aroma (χ^2 = 24.097; df = 8; p = 0.002), taste (χ^2 = 32.881; df = 8; p < 0.001), and texture (χ^2 = 48.542; df = 8; p < 0.001).

Table 3. Friedman Test Results for Sensory Attributes of Ceremoringa Bar

Attribute	X^2	df	p-value
Color	28.502	8	<0.001
Aroma	24,097	8	0.002
Taste	32,881	8	<0.001
Texture	48,542	8	<0.001

The Friedman test showed differences in the assessment between the formulations. Further analysis was performed using the Wilcoxon signed-rank test with Bonferroni correction to evaluate the paired differences between the formulations.

Table 4. Results of the Wilcoxon signed-rank test (post-hoc) with Bonferroni correction

Attribute	Comparison	Z	p-value	p-value (Bonferroni)
Color	3C vs 1A	-0.443	0.658	1.000
Color	3C vs 1C	-0.707	0.480	1,000
Color	3C vs 2C	-1.498	0.134	0.402
Aroma	1C vs 2C	-0.266	0.790	1.000
Aroma	1C vs 3C	-0.816	0.414	1,000
Aroma	1C vs 1B	-0.233	0.816	1.000
Taste	1A vs 1B	-0.775	0.438	1,000
Taste	1A vs 1C	-1.318	0.188	0.564
Taste	1A vs 3C	-1.148	0.251	0.753
Texture	3C vs 1C	-1.459	0.145	0.435
Texture	3C vs 3B	-1.279	0.201	0.603
Texture	3C vs 1A	-1.476	0.140	0.420

The significance level after Bonferroni correction was set at p < 0.0167

Although the Friedman test showed significant differences overall, the Wilcoxon signed-rank test with Bonferroni correction did not show significant differences between the compared formulation pairs. This indicates that the differences in sensory acceptance were general between formulations, without any one formulation pair being consistently significantly different.

Proximate Analysis

Proximate analyses were performed on the apple and strawberry variants. Each 10 g bar of Ceremoringa provides approximately 42 kcal, with the strawberry version containing slightly higher levels of protein (0.90 g) and vitamin C (2.85 mg) than the apple version.

Table 5. Composition per 100g Snack Bar

Nutrients	Strawberry		Apple	
	100 g	10 g	100 g	10 g
Energy (kcal)	417.7	41.8	426.2	42.6
Protein (g)	8.96	0.90	7.12	0.71
Fat (g)	16.97	1.70	16.95	1.70
Carbohydrates (g)	57.29	5.73	61.30	6.13
Vitamin C (mg)	28.52	2.85	21.36	2.14
Iron (Fe) (mg)	0.66	0.06	0.79	0.07

Consuming 5–7 bars of Ceremoringa (50–70 g) per day can contribute 210–290 kcal of energy, which almost meets the additional energy requirements of pregnant women of approximately 300 kcal per day. However, to prevent excessive intake, the consumption of 2–3 bars per day is recommended. The strawberry variant offers higher levels of protein and vitamin C, supporting overall nutritional adequacy, although its iron content is relatively low (<1 mg/100 g).

The results showed that the processing techniques and types of dried fruit used in the production of moringa leaf snack bars had a significant effect on the sensory attributes of color, aroma, taste, and texture, as determined by the Friedman test. However, the Wilcoxon signed-rank test with Bonferroni correction did not reveal any significant differences between the formulation pairs. Based on the median values and interquartile range (IQR) distribution, formulations 1A, 1B, and 3C showed better sensory acceptance than the other formulations. Formulation 1A had the highest median taste attribute, whereas formulation 1B showed stable ratings for taste and aroma attributes. Formulation 3C had a more consistent texture, with a narrower IQR, indicating relatively uniform panelist perceptions. Although no statistically significant differences were observed between the formulation pairs ( ), these findings provide a descriptive basis for determining the formulation with the highest potential for sensory acceptance for further development.

Overall, the panelists rated their preference for Ceremoringa Bar as moderate to high, indicating that the use of moringa leaves in snack bars is acceptable in terms of sensory properties. Significant color differences are mainly influenced by the heating process and the interaction of chlorophyll pigments in Moringa leaves with other ingredients. Chlorophyll, a green pigment in plants that plays a role in photosynthesis, is easily altered when exposed to heat. Research by Amrih et al. (2023) on the effect of cooking on chlorophyll pigments shows that heating can cause the product to turn brown. This occurs because chlorophyll is sensitive to high temperatures; therefore, the heating process, whether using open or closed techniques, can accelerate chlorophyll degradation (Amrih et al., 2023).

In Formulation 2, the cooking process with the addition of water produced a more homogeneous dough, resulting in a more uniform and stable color in the final product. Heating to a certain moisture content can also reduce pigment damage, thereby preserving the green color of the moringa leaves and making them more appealing. From a food technology perspective, the combination of heat and moisture triggers starch gelatinization, creating a softer and more chewable texture. Hydrothermal treatments such as partial boiling are even known to increase grain stiffness, reduce damage during processing, and improve product appearance and acceptance. Several studies have shown that starch granules can become finer after hydrothermal processing, thereby improving their taste and sensory attributes (Tanwar et al., 2025). Unlike formulations that undergo heating, those without heat treatment exhibit product characteristics that are more influenced by the ingredient composition and mixing processes. Nevertheless, the results of this study indicate that with certain ingredient combinations, such as in formulation 3C, the product can still have a relatively uniform color appearance and be acceptable to the panelists.

The aroma did not show any significant differences between the formulations. This is likely because the main aroma sources come from components that are relatively stable during processing, such as the distinctive aroma of moringa leaves and chocolate aroma on the outer layer. Volatile molecules, which are easily detected by the sense of smell in some foods, can remain stable even when heated; therefore, variations in processing do not always result in significant aroma differences between products. Under certain conditions, processing such as baking or fermentation can enhance or alter the aroma profile; however, in this snack bar formulation, the processes used are unlikely to cause significant changes to these volatile compounds (Aprea, 2020). The heating temperature used in this study was not high enough to cause significant changes or evaporation of aromatic compounds, making it difficult for the panelists to distinguish aromas between formulations.

In contrast, the most striking difference between the formulations was their taste and texture attributes. In Formulation 2, the cooking process with water triggers the partial gelatinization of starch in ingredients such as oats and rice krispies, resulting in a denser, more

compact, and uniform product. Gelatinization occurs when starch is heated with water, causing the molecular structure of the starch granules to degrade. The granules then absorb water, expand, and lose their crystallinity. This process increases the viscosity of the dough, making the food thicker, softer, and chewier. In cereal bars, gelatinization plays a role in binding cereal components, making the texture more stable and less prone to crumbling. The right level of gelatinization also helps prevent water loss (syneresis), thereby maintaining product stability. The degree of gelatinization also determines the final texture characteristics; minimal gelatinization preserves the crispness of the cereal, whereas more intense gelatinization produces a softer and chewier texture (Chakraborty et al., 2022). In formulations that do not undergo water addition or full heating, the texture characteristics of the product are more influenced by the composition of the ingredients and mixing process. Under these conditions, starch tends to remain in a granular form, thus failing to form a strong gel structure. Nevertheless, the results of this study indicate that certain ingredient combinations, such as those in Formulation 3C, are still capable of producing a texture that is considered consistent by the panelists, as reflected in the relatively high median value and narrower spread of ratings. These findings indicate that, in addition to the gelatinization process, ingredient formulation factors also play an important role in shaping the taste and texture characteristics of the product (Fitriani et al., 2023).

The type of dried fruit used also contributed to the taste perception of the product and the level of acceptance by the panelists. Strawberries have a stronger and slightly more acidic taste than apples or papayas, making them easier to recognize. In some formulations that undergo cooking, the taste of strawberries tends to blend better with the base ingredients, as reflected in the relatively higher median taste rating. In formulations without heat treatment, the interaction between the base ingredients and dried fruit was more dependent on the composition and mixing process. Under these conditions, the flavor characteristics of each fruit can be more prominent but still remain within the panelists' acceptance range. These findings indicate that, in addition to processing techniques, the selection of dried fruit types plays a role in shaping the flavor profile of the Ceremoringa Bar.

Strawberries are known to have a relatively higher vitamin C content than apples; therefore, they are often considered an ingredient with added nutritional value in the development of food products (Carr, 2025; Coker et al., 2022). Vitamin C plays an important role in various physiological processes, including increasing the bioavailability of non-heme iron through reduction mechanisms and the formation of complexes that maintain iron solubility in the gastrointestinal tract (Rieny et al., 2021; Salwa et al., 2025). Additionally, vitamin C has been reported to play a role in regulating iron metabolism through its association with hepcidin and erythropoiesis (Bhoot et al., 2023; Hardiansyah et al., 2024). In the context of Ceremoringa Bar development, the use of strawberries primarily contributes to the product's sensory characteristics, particularly flavor balance and panelist acceptance. Previous findings on the role of vitamin C during pregnancy and lactation, including its distribution through the placenta and breast milk (Carr, 2025; Coker et al., 2022; Wijayanti & Zulkarnain, 2021), provide a theoretical basis for the potential added value of this ingredient, which can be considered in the development of moringa leaf-based food products in the next stage of research.

However, the iron content in Ceremoringa snack bars is still relatively low; therefore, consumption should be combined with other foods that are richer in iron to meet daily requirements. Among the formulations that showed relatively good sensory acceptance, formulation 3C was considered the main candidate for further development because it had the most consistent texture and a more homogeneous distribution of the ratings. This formulation had a more attractive color, balanced taste, and denser and more stable texture. These findings indicate that the combination of processing methods with the addition of water and the use of strawberries as filling can produce product characteristics that are most preferred by the panelists. Good sensory acceptance is an important factor in the development of functional food products, as it affects sustainability of consumption. Moringa leaves have been widely reported to contain various bioactive compounds, such as flavonoids, polyphenols, alkaloids, saponins, and phytosterols, which have

the potential to provide functional benefits, including galactagogue activity (Rahmad et al., 2022; Dinengsih et al., 2023). Previous studies have shown that the consumption of moringa leaf-based products, in both powder form and other processed food products, is associated with increased breast milk production and improved breast milk nutritional quality (Dinengsih et al., 2023; Pujiastuti et al., 2022).

This study had several limitations that should be considered when interpreting the results. First, sensory testing was conducted using nutrition student panelists; therefore, the sensory assessment results may not fully represent the preferences of the main target group, such as pregnant and lactating women. Second, the relatively limited number of panelists and the use of a repeated-measures design allowed for the possibility of fatigue or sensory adaptation, even though the order of sample presentation was kept as consistent as possible. Third, this study focused on sensory evaluation and proximate analysis; therefore, it did not assess product stability during storage, shelf life, or changes in physical and sensory quality over a certain period. Fourth, although Moringa leaves are known to have functional potential, particularly as galactagogues, this study did not directly evaluate the biological or physiological effects of product consumption on nutritional status or lactation function. Therefore, the results of this study are more appropriately positioned as an initial stage of product development, which requires further study through broader consumer preference testing, product stability testing, and intervention studies to confirm its functional benefits in humans.

Conclusion

This study shows that variations in processing techniques and types of dried fruit affect the sensory characteristics of the moringa bars. Based on the median analysis and IQR distribution, the 3C formulation exhibited the most consistent sensory performance, particularly in terms of texture, and was therefore selected as the most promising formulation for further development. This product is sensorially acceptable with moderate to high preference levels and provides approximately 42 kcal per 10 g. Ceremoringa Bar has the potential to be developed as a moringa leaf-based snack with added nutritional value. However, its potential to support breastmilk production requires further investigation. Further research is recommended to include product stability testing, consumer acceptance testing in target groups and controlled clinical trials.

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